THE GROWTH-PROMOTING VALUES OF THE PROTEINS OF SOYBEAN FLOUR, PEANUT FLOUR, AND COTTONSEED FLOUR--THEIR VALUES AS SUPPLEMENTS TO THE PROTEINS OF WHEAT AND PATENT WHEAT FLOUR*

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The World War has developed a situation that threatens a shortage of protein foods, particularly proteins from animal sources--meat, milk, and eggs. In fact, such a shortage is believed to be already impending, and that it will increase not only with the duration of the war, but for some time after hostilities have ceased. This situation demands that immediate consideration be given to the nutritional value of plant proteins that may serve in the diet.

There are three important agricultural crops that offer excellent possibilities for supplying plant proteins having a high nutritive value, and which are eminently suitable for use as human food in a variety of ways. These products are soybeans, peanuts, and cottonseed. Soybean flour for human consumption is already being produced in increasing quantities. Peanut and cottonseed flours are also being produced in limited quantities. The potential production of these seed crops is enormous.

The protein nutritional value of a food depends not only on the quantity of protein present but also on the kind of protein. If a protein does not contain all of the ten nutritionally-essential amino acids in adequate amounts it will not support growth or maintain an animal in a satisfactory state of health and nutrition no matter how much is eaten. The question of protein requirements in nutrition is essentially a question of amino acid requirements. This does not mean, however, that a protein lacking in one of these amino acids may not serve a very important place as a protein food in the diet, since this deficiency can be corrected by the use of other proteins that contain the amino acid in abundance.

Practical feeding tests with farm animals as well as laboratory studies with small experimental animals have demonstrated that soybeans, peanuts, and cottonseed supply proteins of high nutritive value. However, there are little or no data available to show just how much better, if any, are the proteins of one than the other, or to indicate their specific values for supplementing protein deficiencies of other commonly used foods. Various reasons account for this lack of informational data. There are few reliable data on the amino acid composition of whole seeds or of their flours. Amino acids have been determined on only isolated, purified proteins, and the results do not represent the amino acid content of the whole seed or of its products as they are used for food. Furthermore, feeding studies in different laboratories have not been conducted under uniform conditions and procedures. Consequently, the data obtained are not comparable. There have been variations in the types

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of diets used, levels of protein in the diets, duration of the feeding periods, the kind and strains of animals used, and differences in the ages and weights of the animals used. Addition of yeast and other protein-containing materials to the diets to supply vitamins have also made comparisons of results impossible.

Most proteins, particularly plant proteins, vary greatly in the proportions of the different amino acids they contain. This fact emphasizes the wisdom of not depending on any one protein alone to provide for satisfactory nutritional requirements. The proteins of soybeans, peanuts, and cottonseed differ widely in their content of some of the nutritionally-essential amino acids, and consequently may vary in their value for supplementing other proteins commonly used in the diet. As sources for supplying proteins to meet the threatened shortage they also have the economic advantage that each crop is produced in different sections of the country.

It is estimated that 36 percent of the protein used for human consumption in the United States is furnished by grains, chiefly by wheat. It would, therefore, seem that one of the most practicable and efficient ways of utilizing soybean, peanut, and cottonseed proteins would be in combination of their flours with wheat flour. Wheat flour is known to be deficient in some amino acids that are abundantly present in soybeans, peanuts, and cottonseed. It has long been known that a palatable and nutritious bread can be made from a mixture of white flour and peanut or soybean flours. Such a mixture can be used also in many other ways.

Studies recently conducted in our laboratory on the comparative growth-promoting values of the proteins of soybean, peanut, and cottonseed flours, and also on their values for supplementing the proteins of wheat and patent wheat flour, have given some rather striking results.

Albino rats were fed diets in which the protein factor was supplied exclusively by the flours, and in the same quantity. The diets used were similar in every respect except for the kind of protein supplement under investigation, and the experimental conditions and procedures were as much alike as possible in every respect. Twelve young albino rats were used in each group, equally divided with respect to sex and litter mates, and having initial weights of 56 to 60 grams. The feeding periods were 42 days. The experiments were conducted in an air-conditioned room at a temperature maintained at 76° ± 3° or 4° F.

The flours studied were incorporated in the diet so as to supply 9.1 percent of protein. The following crystalline vitamins were added to the diet in amounts adequate to meet the requirements of the animals for the B-complex; thiamine, riboflavin, pyridoxine, calcium pantothenate, nicotinic acid, and choline. Cod liver oil (2%) furnished vitamin A. Osborne and Mendel's salt mixture supplied the mineral elements. Autoclaved starch was used as required to adjust the diets to a protein content of 9.1 percent. The diets also contained 8 percent of fat, supplied partly by the oil-seed flours used, and the balance by addition of corn oil.

The soybean, peanut, and cottonseed flours were expeller type of commercial products produced for human consumption, and contained 5.7, 8.1, and

15.4 percent fat, respectively. The patent wheat flour was commercially milled from the same wheat as was used. The whole wheat was ground to a fine meal in an experimental mill in the laboratory.

Altogether, fourteen lots of animals were used. The first five were used to determine the comparative protein values of the three oilseed flours, whole wheat, and the patent wheat flour when fed separately at 9.1 percent protein level. The other nine lots were fed mixtures in order to determine the relative values of the proteins of the oil-seeds for supplementing the proteins of the patent wheat flour. The mixtures consisted of 5, 10, and 15 parts of the oil-seed flours, and 95, 90, and 85 parts of the wheat flour, respectively. The results are shown in the accompanying table. Inasmuch as the vitamin and mineral supplements were supplies in all the diets, the weight gains given represent protein values exclusively.

The figures in the first column show the average weight gains of the animals in each group over a period of 42-days. The second column shows the average gains in weight per gram of protein eaten and the last column the average food consumption during the 42-day periods. In every case the food contained 9.1 percent of protein. Comparing the first five sets of figures we see that the animals grew almost twice as much on the whole wheat as on the patent flour and almost four times as much on peanut flour. When calculated on the basis of grain in weight per gram of protein consumed the soybean flour was significantly superior to cottonseed flour.

Of particular interest are the results obtained with the mixed flours. A mixture consisting of only 5 parts of peanut flour and 95 parts of patent flour had a growth value of 29 grams as against 19 grams for white flour alone. Raising the proportion of peanut flour to 10 percent and to 15 percent increased the values to 44 and 48 grams, respectively. Addition of cottonseed flour gave results quite close to those obtained with the corresponding proportions of peanut flour. Soybean flour, on the other hand, gave quite superior values. The mixtures containing 5 parts of soybean flour showed a growth value somewhat greater than that of whole wheat, while those containing 10 and 15 parts supported growth gains nearly four and five times that obtained with patent flour alone.

The increasing weight gains obtained with increasing proportions of the oil-seed flours added to the patent flour indicate definitely that the oil-seed proteins supply one or more nutritionally-essential amino acids that are not present in sufficient amounts in the wheat flour proteins. There can be little or no doubt that one of these amino acids is lysine. Most of the protein of wheat flour is contained in the gluten. Gluten contains only about 2 percent of lysine. One of the two proteins composing gluten is gliadin which contains little or no lysine. This protein is frequently referred to as a classic example of a deficient protein. Animals receiving no other protein than gliadin in their diet will die in a comparatively short time. However, when lysine is added to the gliadin diet growth can be maintained at a very fair rate.

Now, how about the oil-seeds as a source of lysine? The proteins of cottonseed and peanuts contain about 4 and 5 percent of lysine, respectively. Glycinin, a protein fraction that represents most of the total protein of the soybean contains 9 percent, a content that is exceeded by few food proteins.

No wonder, then, that 15 parts of peanut flour or of cottonseed will more than double the growth-promoting value of white flour, and that the same proportion of soybean flour will increase the value almost five-fold.

Lysine is only one of the ten nutritionally-essential amino acid components of proteins. Although it is the chief limiting amino acid in the proteins of patent flour, there are probably other amino acids that enter into the picture. Some of the results shown in the table suggest that such is the case. When fed alone in the ration cottonseed flour gave significantly higher weight-gains values than peanut flour, but there was not much difference in their values as supplements to wheat flour. It is also of interest to note that Lot 291 fed the flour mixture containing 15 parts soybean flour and 85 parts white flour gained more than Lot 288 fed on the straight soybean diet. This suggests that the wheat flour may have contributed some amino acid that is not supplied by the soybean flour in quite sufficient quantity. It is possible that a mixture of the three oil-seed flours would enhance the protein value of wheat flour more than the use of any one of them alone.

It should be emphasized that greater weight gains than those here recorded would have resulted had a higher level or protein been used in the rations. They would not, however, have offered as satisfactory comparisons. The rather low level of 9.1 percent was chosen for several reasons. Since the wheat flour used contained only a little over 10 percent protein 9.1 percent of protein was the highest that could have been used with the necessary allowance for the minerals, fat, and cod liver oil incorporated in the ration. More efficient utilization of a protein is accomplished when it is present in the ration at a low level than that at a high level. Amino acid deficiencies in proteins will manifest themselves more sharply at low protein levels and thus enable a better comparison of values when a series of different proteins are being studied.

The results of the studies here outlined indicate that the use of soybean, peanut, and cottonseed flours offers one of the most effective, economical, and practical ways of meeting the world shortage of protein foods that seems imminent, and that this may best be accomplished by their use in conjunction with wheat flour. This country has an abundance of wheat, and wheat flour is one of the most extensively used foods. It is economical and can be used in an almost unlimited variety of ways. Bread made of a mixture of white wheat flour and 10 to 15 parts of soybean or peanut flours is scarcely distinguishable in taste or appearance from bread made of white flour alone.

No matter how many vitamins or how many mineral elements may be supplied in the diet, satisfactory growth will not result if any one of the ten nutritionally-essential amino acids be lacking. Wide publicity is being given to so-called "enriched" flour as a great development in improving the nutritive value of wheat flour. The enrichment consists in the addition of two vitamins (thiamine and niacin) and one mineral element (iron). The product is still as deficient in protein value as it was before enrichment. The results of our experiments show that, even after enrichment with eight vitamins and twelve mineral elements, the growth-promoting value of white flour can be still increased two-fold by protein supplementation with 10 parts of peanut or cottonseed flours, and four-fold with soybean flour.